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Physics and medical applications of cold atmospheric plasma

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Recent progress in atmospheric plasmas led to the creation of cold plasmas with ion temperature close to room temperature. Varieties of novel plasma diagnostic techniques were applied in a quest to understand physics of cold plasmas. In particular it was established that the streamer head charge is about 10^8 electrons, the electrical field in the head vicinity is about 10^7 V/m, and the electron density of the streamer column is about 10^{19} m^3. We have demonstrated the efficacy of cold plasma in a pre-clinical model of various cancer types (lung, bladder, breast, head, neck, brain and skin). Both *in-vitro* and *in-vivo* studies revealed that cold plasmas selectively kill cancer cells. We showed that: (a) cold plasma application selectively eradicates cancer cells in vitro without damaging normal cells. (b) Significantly reduced tumor size *in viv*o. Cold plasma treatment led to tumor ablation with neighbouring tumors unaffected. These experiments were performed on more than 10 mice with the same outcome. We found that tumors of about 5mm in diameter were ablated after 2 min of single time plasma treatment. The two best known cold plasma effects, plasma-induced apoptosis and the decrease of cell migration velocity can have important implications in cancer treatment by localizing the affected area of the tissue and by decreasing metastasic development. In addition, cold plasma treatment has affected the cell cycle of cancer cells. In particular, cold plasmainduces a 2-fold increase in cells at the G2/M-checkpoint in both papilloma and carcinoma cells at $\sim$24 hours after treatment, while normal epithelial cells (WTK) did not show significant differences. It was shown that reactive oxygen species metabolism and oxidative stress responsive genes are deregulated. We investigated the production of reactive oxygen species (ROS) with cold plasma treatment as a potential mechanism for the tumor ablation observed.